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Construe of Five Green Adsorbent for Water Remediation with One Chemical Adsorbent

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ABSTRACT
Proficient process for the fabrication of benevolent adsorbent with Zinc oxide nanoparticle embedded on activated silica (ZnO- NPs-AS) exclusive of calcinations was developed by green synthesis method using aqueous leaf extract of *Ocimum sanctum, Acalypha*

indica Emblica officinalis, Azadirachta indica, Corriandrum sativum. The method involved the use of zinc acetate dehydrate (Zn $(CH_3COO)_2 \cdot 2H_2O$) and sodium hydroxide (NaOH) as a precursor and aqueous extract of *plants* as a solvent with manifold roles as promoter, stabilizer and template for synthesis of zinc oxide nanoparticle. Adsorption behavior of benign adsorbents was applied to Freundlich, Langmuir, Tempkin, and BET Isotherm which afford important information on the surface properties of the adsorbent and its affinity for adsorbate. Data correctly fits Langmuir isotherm than Freundlich, Tempkin and BET isotherm proving monolayer and homogenous surface of adsorption with R^2 nearly 0.992, 0.989, 0.970, 0.974, 0.968 and 0.956. In this study pseudo second order model fitted better (R^2=0.982, 0.603, 0.732, 0.906, 0.603 & 0.732.) when compared with first order kinetic model. Therefore the adsorption data in the present study supported chemisorption. The linearity of the plots also showed the validity of pseudo-second order model. The sequence of adsorption of adsorbent follows ZnO-NPs-AS-*Os*> ZnO-NPs-AS-*Ai* >ZnO-NPs-AS-*AZi* >ZnO-NPs-AS-*Eo* >ZnO-NPs-AS-*Cs*> ZnO-NPs-AS.

KEY WORDS: Adsorbent, Isotherm, Kinetics, ZnO-NPs-AS

1. INTRODUCTION

Swift industrialization has led to remarkable bloat in the use of heavy metals. Over the precedent predictably resulted in an increased flux of metallic substances in the aquatic environment. The decisive environmental confront for industry is the safe disposal of wastewater. Among the assorted industries, electroplating units are the most imperative because of their lucrative applications. In contrast to other industries, the electroplating units use less water, thus produce small volume of wastewater which is highly toxic in nature because of the presence of hazardous metals such as Ni(II), As(III), Zn(II), Pb(II), As(V), Cr(VI) and Cd(II). Varied treatment technologies have been developed for the exclusion of these metals from wastewater, such as precipitation, oxidation/reduction, coagulation flocculation, electro coagulation, cementation, membrane separation, membrane filtration, solvent extraction, ion exchange and adsorption depending on the concentration of these metals. In regard of its simplicity and high-efficiency characteristics, the adsorption process are one of the few alternatives accessible for the removal of heavy metals at low concentrations from industrial effluents, it is an effectual inexpensive and proficient method (Senthil Kumar et al., 2009, Murugesan et al., 2006). Adsorption technique is quite trendy due its simplicity and high efficiency, as well as the ease of use of a wide range of adsorbents. Various adsorbents have been tested and used for the removal of heavy metals from polluted water. Among the kinds of adsorbent, Metal Oxide nano adsorbent have been attracted interesting recently because it exhibit high surface area to volume ratio. However, the other methods have momentous disadvantages such as incomplete metal removal, particularly at low concentrations and high capital investment as well as creating sludge disposal problem. These heavy metals reach tissues through the food chain and accumulate in the human body. If the metals are ingested beyond the permitted concentration, they can cause serious health disorders. Therefore it is necessary to treat metal contaminated waste water prior to its discharge to the environment. The World Health Organisation (WHO1993) recommends a maximum acceptable concentration of Cu (II), Ni(II), As (III) and Zn(II) in drinking water of 2, 0.02, 0.001 and 3 mg/ L respectively. Symptoms of arsenic poisoning begin with headaches, confusion, severe nausea and drowsiness. The poisoning develops convulsions and changes in fingernail pigmentation called leukonychia. When the poisoning becomes acute symptoms may include vomiting, blood in the urine, cramping muscles, hair loss, stomach pain and more convulsions. The organs of the body that are usually affected by arsenic poisoning are the lungs, skin, kidneys and liver. The final result of arsenic poisoning is coma and death. It is therefore essential to search benevolent product and to transform such materials to adsorbents. Increasing awareness towards green chemistry and biological processes has led to the efficacy and feasibility of an eco-friendly approach (Gunalan sangeetha et al., 2011 , Tseng et al., 2003) for the synthesis of ZnO nanoparticle ingrained on activated silica as proficient adsorbent for removal of As(III).The present work investigates the potential use of different adsorbents (ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*AI*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZI*, ZnO-NPs-AS-*Cs* and ZnO-NPs-AS) prepared from from aqueous plant extracts like *Ocimum sanctum, Acalypha indica, Emblica officinalis, Azadirachta indica, Corriandrum sativum* for the removal of As(III) and zinc oxide nanoparticle ingrained on activated silica by chemical method.

2. MATERIALS AND METHODS

2.1. Preparation of Activated Silica (AS)

Activated silica (AS) is prepared by treating silica at a temperature of 500ºc for 6 hrs. The thermal pretreatment always increases the available active sites and increases adsorption capacities. The properties of coated silica (ZnO-NPs-AS) with plant extract are clearly different from that of uncoated activated silica (AS) leading to a change in specific surface area, pore size and pore volume.

2.2. Synthesis of Green Adsorbent

Green synthesis method was used to prime down five different adsorbent (ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi*, ZnO-NPs-AS-*Cs)* from plants like *Ocimum sanctum, Acalypha indica, Emblica officinalis, Azadirachta indica, Corriandrum sativum*. 0.25ml, 0.5ml and 1ml aqueous leaf extracts of the respective plant was introduced into 250ml beaker with 50ml of distilled water and was vigorously stirred for 30 minutes in five different sets. Then 1g of Zinc acetate dihydrate ($Zn\ (CH_3\ COO)_2.\ 2H_2O$) was added and stirred. After 1 hr stirring 10g of activated silica was introduced into the above solution. Addition of drops of aqueous NaOH resulted in a white aqueous solution at pH 10-12. This was then positioned in a magnetic stirrer for 2 hrs. ZnO nanoparticle ingrained on activated silica were then filtered and washed with double distilled water. The synthesized ZnO-NPs-AS with plant extract was maintained at 60ºC for 12 hrs. A mortor was used to homogeneously ground the adsorbent (ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi*, ZnO-NPs-AS-*Cs* and ZnO-NPs-AS). The proposed sorbent were stored in air at room temperature.

2.3. Characterization of Adsorbent

The external morphology and percentage elemental composition of the sample were characterized by scanning electron microscope (SEM) (LEO 1530FEGSEM) with Energy Dispersive X-ray Analysis (EDAX).

3. EXPERIMENTAL DETAILS

Sequence of batch adsorption experiments was conducted to resolve the effect of adsorbent (ZnO-NPs-AS) in the removal of As (III). Therefore various adsorbent dosages of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5 and 8.0g were introduced into 250mL flasks with 20mL solution containing 0.005, 0.0075, 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09 and 0.10 N of As (III) ions. The flasks were then placed in an orbital shaker at an agitation speed of 50, 100, 150, 200, 250, 300, 350, 400, 450 and 500 rpm. Samples were taken at predetermined time intervals of (10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110 and 120 minutes) in a pH range of 1, 2, 3, 4, 5, 6, 7 and 8 and then separated by centrifugation. Concentration of As (III) ions in aqueous phases were analyzed volumetrically in duplication to observe the reproducibility. The effect of each parameter is studied by changing one parameter progressively by keeping the others constant. The parameter obtained from different models of isotherms like Freundlich, Langmuir, Temkin and Brunauer Emmet Teller (BET) provides important information on the surface properties of the adsorbent and its affinity. The physisorption and chemisorption kinetic rate equation is determined using Pseudo first and second order rate equation. The quantity of As (III) adsorbed by adsorbent was calculated using the following formula:

$\%\ Removal = (C_0-C_e) \times 100 / C_0$ ----- (1)

$q_e = (C_0-C_e) \times V / W$ ----- (2)

Where C_o and C_e are initial and equilibrium concentration of As(III), q_e the amount of As (III) adsorbed under given condition, V the volume of the solution (ml) and W the weight (g) of the adsorbent used (Pokhrel et al., 2007 and Bhattacharya et al., 2006).

4. RESULTS AND DISCUSSION

4.1. Effect of Concentration

The adsorption capacities of different adsorbents (ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi*, ZnO-NPs-AS-*Cs* and ZnO-NPs-AS) per initial concentration are represented in figure 1. Different adsorbent capacities might be due to various factors such as solubility, size and affinity of adsorbent, surface area, pore volume and the phytoconstituents of the respective plant. At lower initial concentration the adsorption ability was significantly higher for ZnO-NPs-AS-*Os* and ZnO-NPs-AS-*Cs* than other

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adsorbents. The percentage removal of As (III) for ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi*, ZnO-NPs-AS-*Cs* and ZnO-NPs-AS are 92.38%, 79.47%, 85.96%, 89.47, 92.38% and 79.6%.

The percentage removal decreases with increase in initial As (III) concentration and the percentage removal of As(III) was almost complete nearly at 0.07 N, 0.03 N, 0.02 N, 0.05 N, 0.03 N and 0.02 N for the adsorbents (ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi*, ZnO-NPs-AS-*Cs* and ZnO-NPs-AS. It reduces to 59.28%, 61.61%, 47.4%, 60.05%, 80.01% and 47.4% at 0.07 N, 0.03 N, 0.02 N, 0.05 N, 0.03 N and 0.02 N for adsorbents (ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi*, ZnO-NPs-AS-*Cs* and ZnO-NPs-AS). Marginally higher adsorption at lower concentration may be due to the high collision efficiency between the metal ions and the adsorbent (Orhan et al., 1993 and Ridvan et al., 2003). At higher concentration there may be lack of available sites for adsorbing As(III) ions on the adsorbent surfaces and may prevent further adsorption of metal ions. The hierarchy of adsorption of the adsorbent in terms of concentration is as follows: ZnO-NPs-AS-*Os* = ZnO-NPs-AS-*Cs* > ZnO-NPs-AS-*AZi*, > ZnO-NPs-AS-*Ai* > ZnO-NPs-AS-*Eo* > ZnO-NPs-AS.

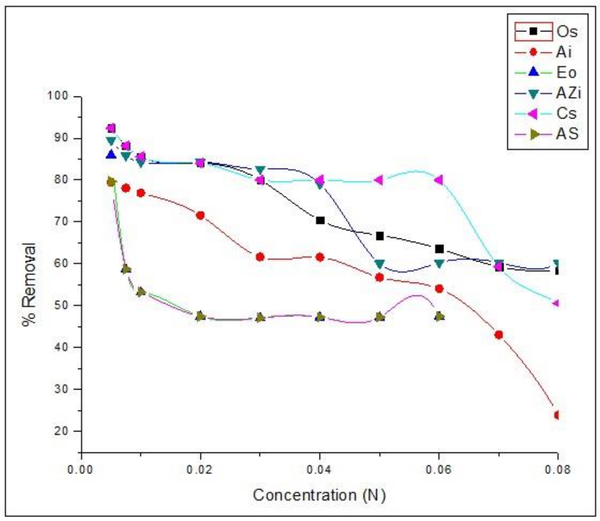

Figure 1

Comparative Effect of Concentration of Five Green Adsorbents with One Chemical Adsorbent

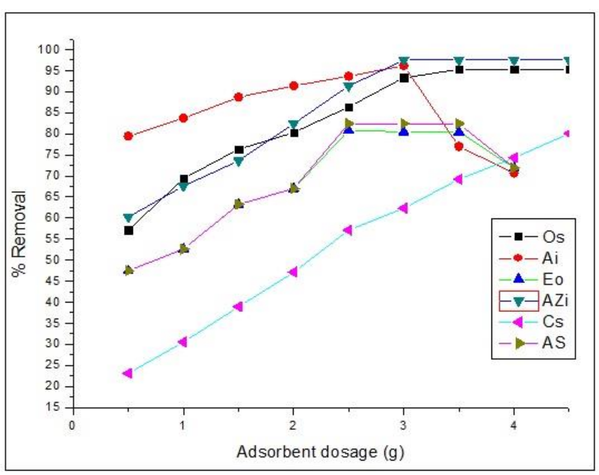

Figure 2

Comparative Effect of Adsorbent Dosage of Five Green Adsorbents with One Chemical Adsorbent

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4.2. Effect of Adsorbent Dosage

Figure 2 indicates the amount of adsorbent dosage on As(III) uptake from 6 different adsorbent (ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi*, ZnO-NPs-AS-*Cs* and ZnO-NPs-AS). Increase in adsorbent dosage from 0.5g to 8g increases the removal of As(III). At 0.5g the removal of As(III) is 57.11% for ZnO-NPs-AS-*Os*, 79.47% for ZnO-NPs-AS-*Ai*, 47.46% for ZnO-NPs-AS-*Eo*, 60.26% for ZnO-NPs-AS-*AZi*, 23.12% for ZnO-NPs-AS-*Cs* and 47.46% for ZnO-NPs-AS (Akhtar et al., 2004). The maximum removal reached upto 95.3% for ZnO-NPs-AS-*Os*, 91.38% for ZnO-NPs-AS-*Ai*, 80.83% for ZnO-NPs-AS-*Eo*, 97.5% for ZnO-NPs-AS-*AZi*, 96.32% for ZnO-NPs-AS-*Cs* and 82.43% for ZnO-NPs-AS. The hierarchy of adsorbent for As(III) removal is as follows: ZnO-NPs-AS-*AZi* > ZnO-NPs-AS-*Ai* > ZnO-NPs-AS-*Os* > ZnO-NPs-AS > ZnO-NPs-AS-*Cs* > ZnO-NPs-AS-*Eo* at 3g dosage. This means that at greater than 3.5g adsorbent dosage, adsorption of the adsorbent got lowered. Hence optimal adsorbent dosage for all adsorbent is selected to be between 3 to 3.5g.

4.3. Effect of pH

It is well known that adsorption of As (III) ions depend on pH of the aqueous solution. Figure 3 indicated the effect of pH on As(III) adsorption by different ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi*, ZnO-NPs-AS-*Cs* and ZnO-NPs-AS. The pH of the solution was varied from 1 to 8 while As(III) removal was 54.58 %, 70.6%, 40%, 41.21%, 65.6% and 38.51% for ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi*, ZnO-NPs-AS-*Cs* and ZnO-NPs-AS at pH 1 respectively. This situation indicates that the adsorbent ZnO-NPs-AS-*Os* is not very different from ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi*, ZnO-NPs-AS-*Cs* and ZnO-NPs-AS except ZnO-NPs-AS-*Ai* at low pH 1 from As(III) removal at low pH values. The removal of As(III) increased rapidly at pH values from 5 to 6 and reached maximum upto 98.35% for ZnO-NPs-AS-*AZi*. The sequence is as follows: ZnO-NPs-AS-*AZi* >ZnO-NPs-AS-*Os* > ZnO-NPs-AS-*Ai* = ZnO-NPs-AS-*Cs* > ZnO-NPs-AS-*Eo* > ZnO-NPs-AS. At pH 6 As(III) ions compete with each other for the surface of the adsorbent , which would hinder As(III) ions from reaching the binding sites of the sorbent caused by the respective forces (Parab et al., 2006). So the metal removal is minimum presumably due to the enhanced competition of proton with As (III) for ligand binding sites and complex formation. Hence at pH > 6 the As (III) ions get precipitated and the removal of As(III) gets decreased the optimal pH was selected to be 5-6 for all adsorbents.

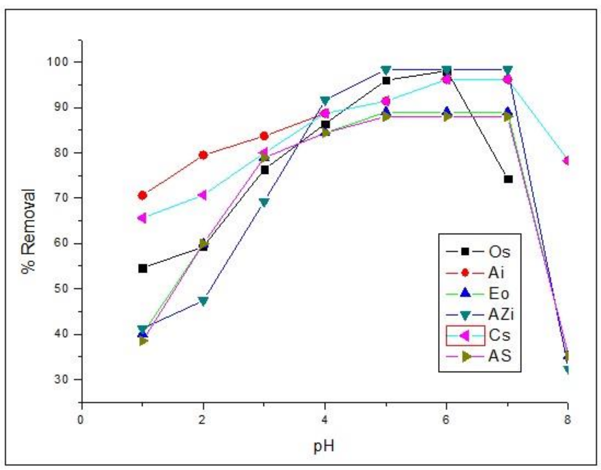

Figure 3

Comparative Effect of pH of Five Green Adsorbents with One Chemical Adsorbent

4.4. Effect of Contact Time

The effect of contact time (Figure 4) on the adsorption of As (III) was investigated at different time intervals on the range of 10-120 minutes. The equilibrium adsorption was established rapidly within 90 min indicating that the initial adsorption was very fast and maximum uptake was reached within 50 minutes for ZnO-NPs-AS-*Os* and ZnO-NPs-AS-*AS* with the maximum As (III) removal of 96.11% and 88%. 60 minutes for ZnO-NPs-AS-*Ai* and ZnO-NPs-AS-*Eo* with maximum As (III) removal of 96.11% and 88%, 40 minutes for ZnO-NPs-AS-*AZI* with 98.35%, 90 minutes for ZnO-NPs-AS-*Cs* with 95.33%. Maximum uptake of As(III) was reached within 40-60

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minutes, thereafter the amount of adsorption remained almost constant except for ZnO-NPs-AS-*Cs*. This was due to the decrease of adsorption sites on adsorbents which gradually interacted with the As(III) ions, but the adsorption rate depends on the As(III) ions, which transported from the bulk liquid phase to the actual adsorption site (Yu et al ., 2003 and Zhu et al., 2009). In this study As (III) adsorbed onto ZnO-NPs-AS-*Os* is 97.29%, ZnO-NPs-AS-*Ai* is 96.11%, ZnO-NPs-AS-*AZi* is 98.35% and ZnO-NPs-AS-*Cs* is 95.33% but only 88% for ZnO-NPs-AS and ZnO-NPs-AS-*Eo*. On the basis of these results, it can be observed that, ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*AZi* and ZnO-NPs-AS-*Cs* can be used to remove metal ions when compared with ZnO-NPs-AS-*Eo* and AS. The removal capacity for different adsorbent was in the order of ZnO-NPs-AS-*AZi* > ZnO-NPs-AS-*Os* > ZnO-NPs-AS-*Ai* > ZnO-NPs-AS-*Cs* > ZnO-NPs-AS-*Eo* Ξ ZnO-NPs-AS. It is indicated that ZnO-NPs-AS-*AZi* showed stronger preference for As (III) uptake than other adsorbents with a contact time of 40 minutes.

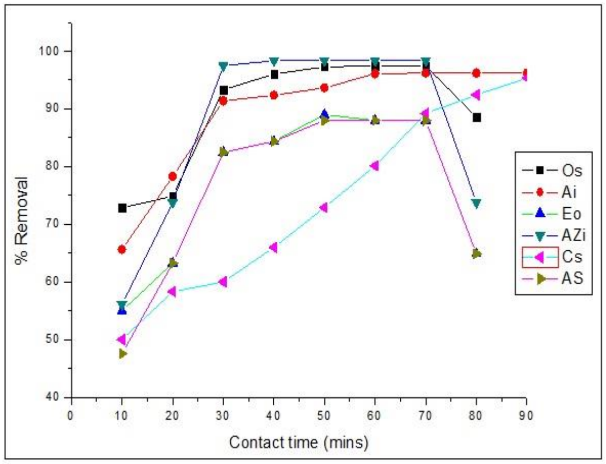

Figure 4

Comparative Effect of Contact Time of Five Green Adsorbents with One Chemical Adsorbent

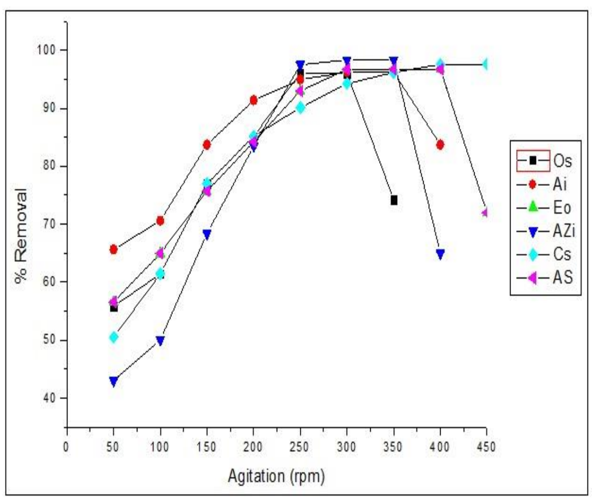

Figure 5

Comparative Effect of Agitation of Five Green Adsorbents with One Chemical Adsorbent

4.5. Effect of Agitation

It was found from figure 5 that the rate of removal of As (III) increases with increase in agitation time to some extent. The initial rapid adsorption subsequently gives equilibrium within a period of 250 rpm to 300 rpm for all adsorbents except ZnO-NPs-AS-*Cs*. The variation in percentage removal of As (III) with agitation speed at different rpm ranging from 50 rpm to 500 rpm is shown in figure 29. It was observed that the maximum amount of As(III) adsorption takes place within 250 rpm to 300 rpm and it reaches

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equilibrium at 300 rpm for all adsorbents (ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi* and AS) except ZnO-NPs-AS-*Cs*. After that no significant change was observed in the extent of adsorption (Kurniawan et al., 2006). The percentage of As (III) removal increased from 55.85%, 65.62%, 56.58%, 43.03%, 50.5% and 56.58% for ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi*, ZnO-NPs-AS-*Cs* and ZnO-NPs-AS to 96.02%, 96.19%, 96.7%, 98.31%, 97.56% and 96.7. This is due to the fact that with increase in agitation speed increases the mass film boundary of the adsorbents (ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi* and AS) which inhibits adsorption(.The hierarchy of adsorption of As(III) for adsorbents is as follows: ZnO-NPs-AS-*AZi* > ZnO-NPs-AS-*Cs* > ZnO-NPs-AS-*Ai* > ZnO-NPs-AS-*Eo* > ZnO-NPs-AS-*Os* > ZnO-NPs-AS .

4.6. Equilibrium Study

In order to know As(III) adsorption behavior, the experimental data were applied to Freundlich, Langmuir, Tempkin Isotherm and BET(Ankamwar et al., 2005 and Bar et al., 2009). Table 1 shows the parameters obtained from different models which afford important information on the surface properties of the adsorbent and its affinity for adsorbate. Several conventional isotherm equations fitted to Freundlich, Langmuir, Tempkin Isotherm and BET. Linear correlation coefficients for these equations determined by linear regression for Freundlich, Langmuir, Tempkin Isotherm and BET showing that data correctly fits Langmuir isotherm than Freundlich isotherm ,Tempkin isotherm and BET proving monolayer and homogenous surface of adsorbent with R^2 nearly 0.992, 0.989, 0.970,0.974,0.968 and 0.956 for (ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi,* ZnO-NPs-AS-*Cs* and ZnO-NPs-AS) adsorbents respectively. Table 1 shows the high fit of the Langmuir model among Freundlich, Tempkin Isotherm and BET. The choice of Langmuir model is confirmed by high R^2 value and R_L value (0.176, 0.980, 0.885, 0.305, 0.997 and 0.885) which is between 0 and 1. Hence it confirms the adsorption is favorable monolayer adsorption. Hence (ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi*, ZnO-NPs-AS-*Cs* and ZnO-NPs-AS) can be used as adsorbent because of its high adsorption capacity. The sequence of adsorption of adsorbent is as follows ZnO-NPs-AS-*Os* >ZnO-NPs-AS-*Ai* >ZnO-NPs-AS-*AZi* >ZnO-NPs-AS-*Eo* >ZnO-NPs-AS-*Cs* >ZnO-NPs-AS on the basis of high R^2 value proving Langmuir monolayer adsorption.

Table 1
Comparison of Adsorption Isotherm Parameters

Equilibrium Isotherm	Equilibrium Parameters	Adsorbent ZnO-NPs-AS-*Os*	Adsorbent ZnO-NPs-AS -*Ai*	Adsorbent ZnO-NPs-AS-*Eo*	Adsorbent ZnO-NPs-AS-*AZi*	Adsorbent ZnO-NPs-AS-*Cs*	Adsorbent ZnO-NPs-AS
Freundlich	n	9.09	11.494	2.67	1.35	2.53	2.67
	K_F (L/g)	6.237	13.83	45.39	1.06	1.322	45.28
	R^2	**0.902**	**0.962**	**0.949**	**0.897**	**0.769**	**0.962**
Langmuir	K_L (L/mg)	66.66	0.665	6.451	45.45	0.6138	6.451
	R_L	0.176	0.980	0.885	0.3055	0.9970	0.8857
	R^2	**0.992**	**0.989**	**0.970**	**0.974**	**0.968**	**0.956**
Tempkin	A	1.396	0.16	1.056	1.238	1.14	1.056
	B	0.025	0.008	0.030	0.025	0.10	0.030
	R^2	**0.906**	**0.960**	**0.960**	**0.943**	**0.889**	**0.939**
BET	R^2	**0.990**	**0.979**	**0.909**	**0.956**	**0.949**	**0.987**
	Surface Area (m^2/g)	300 m^2/g	164.2008 m^2/g	302.73 m^2/g	205.4 m^2/g	204.23 m^2/g	410.35 m^2/g
	Pore size (nm)	29.048 Å	44.688 Å	28.048 Å	32.48 Å	30.47 Å	40.048 Å

4.7. Kinetic Study

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Correlation coefficients for these equations determined by linear regression for all kinetic models, pseudo-first and pseudo-second order were worked out. It can be inferred from table 2 that adsorption did not obey well with the pseudo first order model because of the absence of linearity between $\ln(q_e–q_t)$ and t (R^2=0.711, 0.452, 0.208, 0.132, 0.452 & 0.188). In this study pseudo second model fitted better (R^2=0.982, 0.603, 0.732, 0.906, 0.603 & 0.732) when compared with first order kinetic model. Therefore the adsorption data in the present study supported chemisorptions. The linearity of the plots also showed the validity of pseudo-second order model. The adsorption rate (t) decreased with increasing solute concentration. The sequence of adsorbent is as follows ZnO-NPs-AS-*Os*> ZnO-NPs-AS-*AZi* > ZnO-NPs-AS-*Eo* = ZnO-NPs-AS-*Cs* >ZnO-NPs-AS-*Ai* = ZnO-NPs-AS.

Table 2

Comparison of Adsorption kinetics

Adsorption Kinetics	Adsorbent ZnO-NPs-AS-*Os*	Adsorbent ZnO-NPs-AS - *Ai*	Adsorbent ZnO-NPs-AS-*Eo*	Adsorbent ZnO-NPs-AS-*AZi*	Adsorbent ZnO-NPs-AS-*Cs*	Adsorbent ZnO-NPs-AS
Pseudo first order equation	0.711	0.452	0.208	0.132	0.452	0.188
Pseudo second order equation	0.982	0.603	0.732	0.906	0.732	0.603

5. CONCLUSION

This new-fangled green synthesis progress shows that the environmentally benign potent adsorbent (ZnO-NPs-AS-*Os*, ZnO-NPs-AS-*Ai*, ZnO-NPs-AS-*Eo*, ZnO-NPs-AS-*AZi,* ZnO-NPs-AS-*Cs* and ZnO-NPs-AS) for the removal of As(III) primed from leaf extracts of *Ocimum sanctum, Acalypha indica Emblica officinalis, Azadirachta indica, Corriandrum sativum*. Competently wrecked Zinc oxide nanoparticle ingrained on activated silica (ZnO-NPs-AS) using Zinc acetate, sodium hydroxide and activated silica synthesised had assorted roles. The Adsorption parameters for the Langmuir, Freundlich, Temkin and BET isotherms were dogged and the constancy data were best described by Langmuir isotherm and fits pretty well with the experimental records with good correlation coefficient of 0.992, 0.989, 0.970, 0.974, 0.968 and 0.956. The data were analyzed using kinetics models analogous to Pseudo first and second order. All the findings accessible in this study suggested following Pseudo second order equation for the adsorption of As (III) on to ZnO-NPs ingrained on activated silica. From the standards it is consummate that the utmost adsorption corresponds to a saturated monolayer of As (III) molecules on the adsorbent surface persistently. Green methods are being good competent for the chemical procedures, which are environment friendly and convenient. The results confirmed that adsorbent synthesized using aqueous leaf extract is a suitable green stencil to prepare ZNO-NPs embedded on activated silica for removal of As (III).

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